PB-214 161

ASSESSMENT OF AIR POLLUTION DAMAGE TO VEGETATION IN NEW ENGLAND, JULY 1971-JULY 1972

John A. Naegele, et al

Massachusetts University

Prepared for:

Environmental Protection Agency

August 1972

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 214 161

EPA-R5-72-009
August 1972

Socioeconomic Environmental Studies

Assessment Of Air Pollution Damage To Vegetation In New England July 1971 - July 1972 Final Report

NATIONAL TECHNICAL
INFORMATION SERVICE

Office of Research and Monitoring
U.S. Environmental Protection Agency
Washington, D. C. 20460

BY

26

BIBLIOGRAPHIC DATA SHEET	1. Report No. EPA-R5-72-009	2.	3. Recipient's Accession No.
4. Title and Subtitle: Assessment of Air Pollution Damage to Vegetation in New England July 1971 - July 1972			5. Report Date: August 1972 6.
7. Author(s): John Naegele, W. A. Feder, and C. J. Brandt			8. Performing Organization Rept. No.
9. Performing Organization Name and Address: Suburban Experiment Station, University of Massachusetts, 240 Beaver Street, Waltham, Massachusetts 02154			10. Project/Task/Work Unit No. 11. Contract/Grant No. 68-02-0084
12. Sponsoring Organization Name and Address: U.S. ENVIRONMENTAL PROTECTION AGENCY, Office of Research and Monitoring, Washington, D. C. 20460			13. Type of Report & Period Covered: Final 14.

15. Supplementary Notes

16. Abstracts

A regional survey of New England was initiated to determine the economic losses to the agricultural industry from injury caused by air pollutants. Eighty-three investigations were made in 40 countries of the six New England states. Direct air pollution injury was observed in 14 countries and accounted for 29 of the reports. Greatest economic losses were observed on vegetables and agronomic crops as well as on flowers and foliage plants. Direct economic losses were estimated to be approximately $1.1 million for the 1971-72 season. As some incidents were not reported during the survey, continuing annual losses are estimated to be approximately $1.5 million.

17. Key Words and Document Analysis. 17a. Descriptors

Air pollution
Damage
Losses
Agricultural products
Vegetable crops
Ornamental plants
Fruit crops
Sulfur dioxide
Oxidizers
Ethylene

17b. Identifiers/Open-Ended Terms

Air pollution effects (plants)
New England

17c. COSATI Field/Group 13B, 2B

18. Availability Statement: Unlimited I-a	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 26
	20. Security Class (This Page) UNCLASSIFIED	22. Price

FORM NTIS-35 (REV. 3-72) THIS FORM MAY BE REPRODUCED USCOMM-DC 14952-P72

EPA-R5-72-009

Assessment of Air Pollution Damage To Vegetation In New England July 1971 - July 1972 Final Report

by

John A. Naegele, William A. Feder,
and C. Jeffrey Brandt

Suburban Experiment Station
University of Massachusetts
240 Beaver Street
Waltham, Massachusetts 02154

Contract No. 68-02-0084
Program Element No. A11004

Project Officer: Donald G. Gillette

Office of the Director
National Environmental Research Center
Research Triangle Park, North Carolina 27711

Prepared for

OFFICE OF RESEARCH AND MONITORING
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D. C. 20460

August 1972

I-f

EPA REVIEW NOTICE

This report has been reviewed by the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

TABLE OF CONTENTS

	Page
Acknowledgments	IV
Abstract	V
List of Tables and Figures	VI
Introduction	1
Methods	5
Results	6
Discussion	14
Recommendations	16
Appendix: Air pollution injury report form.	17
References	18

ACKNOWLEDGMENT

This survey was supported by Environmental Protection Agency Air Pollution Control Office contract number 68-02-0084 and was carried out at the Suburban Experiment Station of the University of Massachusetts, Waltham, Massachusetts.

Personnel of the Suburban Experiment Station (SES) directly concerned with this survey are:

John A. Naegele, PhD (Entomology)
Director, SES
Project co-director

William A. Feder, PhD (Plant Pathology)
Professor of Plant Pathology, SES
Project co-director

C. Jeffrey Brandt, MS (Plant Ecology, Botany)
Technical Assisstant, Senior Chemist, SES
Principal investigator

Grateful acknowledgment is also extended to support personnel at the Suburban Experiment Station and to agents and specialists of the Cooperative Extension Service of Massachusetts, Connecticut, Rhode Island, Vermont, New Hampshire, and Maine.

LIST OF TABLES AND FIGURES

Table no. Page

I. Land use in New England 3

II. Value of selected crops for New England 4

III. Summary of vegetation damage reports by location 8

IV. Crops affected by particular pollutants 10

V. Direct losses by crop and pollutant 11

VI. Summary of losses by crop and pollutant 12

Figure no.

1. Areas of observed air pollution injury to vegetation 9

Preceding page blank

ASSESSMENT OF AIR POLLUTION DAMAGE TO VEGETATION IN NEW ENGLAND: July 1971-July 1972.

INTRODUCTION

In recent years surveys designed to assess the economic effects of air pollution on vegetation have been carried out in several states, notably California and Pennsylvania. Surveys are necessary to establish substantiated and realistic estimates of the annual losses of agricultural products from air pollution, to indicate areas in which research is needed, and to show the effectiveness or need of air pollution control programs.

In 1969-70 the Center for Air Environment Studies of the Pennsylvania State University conducted such a survey and showed that during that year an excess of $3.5 million was lost to air pollution. A survey conducted the following year indicated direct losses to crops due to air pollution of only $218,630. These differences show the importance of yearly assessment programs and also the effects that meteorological differences, changes in cultural practices, and the addition of pollution controls can have on the results of the survey. The California Department of Agriculture carried out a similar survey and assessment of air pollution damage to vegetation in 1970 and found that the California agricultural industry suffered losses in the neighborhood of $26 million.

The surveys have been very effective in showing the public the extreme effects of air pollutants on the agricultural industry. Several air pollution code violations have been brought to court and control measures have been adopted as a direct result of them.

Using data from these surveys and other available information on vegetation damage, the Stanford Research Institute prepared a mathematical model to estimate losses due to air pollution on a regional and national basis. The SRI estimate for air pollution damage to vegetation in the nation is about $132 million.

In continuing its survey program, the Environmental Protection Agency recognised the necessity for an assessment of vegetation damage along the eastern seaboard. The New England region was chosen for a survey that would reflect the regional extent of air pollution damage for the 1971-72 growing season. A similar survey and assessment was carried out in New Jersey at the same time.

The New England region occupies a land area of approximately 40.3 million acres and is composed of six states: Vermont, New Hampshire, Maine, Massachusetts, Connecticut, and Rhode Island. Of this land area, 16% is occupied by farmland and 71% is covered by forests. Nearly 6 million acres are occupied by the urban sprawl stretching from New York City through Connecticut and Rhode Island to north of Boston (Table I).

Although nearly 50% of the land used in farms is in the states of Vermont, New Hampshire, and Maine, the highest and most diverse agricultural productivity occurs in Massachusetts and Connecticut (Table II). The other New England states are significant for their production of specialty crops suited to the climate and topography of the particular state. Vermont ranks high in production of hay and silage with most farmland devoted to pasturage and dairy farming. Maine is the leading producer of potatoes in the northeast and Rhode Island has large turf and nursery industries. The total dollar value of agricultural productivity in New

Table 1. Land use in New England

State	Farmland*	Forested Land	Other Land Uses**	Total Land Area
		Acres X1000		
Vt.	2,200 (37%)***	3,114 (53%)	621 (10%)	5,935
N.H.	720 (12%)	4,355 (75%)	706 (12%)	5,781
Me.	2,300 (12%)	15,971 (80%)	1,526 (8%)	19,797
Ma.	720 (14%)	2,927 (58%)	1,366 (27%)	5,013
Ct.	600 (19%)	1,795 (57%)	722 (23%)	3,117
R.I.	90 (13%)	387 (57%)	194 (28%)	671
Total	6,630	28,549	5,135	40,314
% of total area	16%	71%	13%	

* Includes crop, fallow, pasture, forest, and other land used in farms.
** Includes urban, industrial, nonfarm residential areas, and related land uses.
*** Figures indicate the percentage of the state total land area in each land use category.

Data from: Agricultural Statistics, 1971.

Table II. Value of selected crops for New England ($Millions/year).

	Vt.	N.H.	Me.	Ma.	Ct.	R.I.	Total
Hay & Silage	32.5	7.5	13.5	9.3	8.3	1.1	72.2
Grains	8.5	1.2	2.6	2.5	3.7	0.4	18.9
Fruits & Maple syrup	4.5	3.6	4.4	20.1	4.0	0.5	37.1
Vegetables		0.6	1.5	10.1	6.2		18.4
Potatoes	0.7	0.5	64.3	2.9	3.3	3.5	75.2
Tobacco				11.8	27.3		39.1
Cut Flowers				7.7	5.2		12.9
Total	46.2	13.4	86.3	64.4	58.0	5.5	274.5

Based on 1970 statistics from Agricultural Statistics, 1971.

England is approximately $275 million/year. While agriculture in the New England is not a major industry when compared with the United States as a whole or even with the agricultural industry of some individual states, it is definately important on a regional basis and continues to contribute to the welfare of the two large Eastern markets in Boston and New York City.

Because the New England growing season is influenced by air masses which carry pollutants northward along the entire eastern seaboard, problems relating to the air environment are likely to assume great importance for agricultural production in the region. Unless measures are taken to assess and deal with these problems it is highly likely that the New England region will have to alter agricultural emphasis with the possible loss of economic stability.

METHODS

This survey was carried out with the co-operation of the county agricultural agents and extension specialists of the six New England states and air pollution specialists at the Suburban Experiment Station, University of Massachusetts, Waltham. It was designed to cover the entire region, with emphasis on Massachusetts and Connecticut. Before the survey started, a three-day short course was held at the Suburban Experiment Station to acquaint the county agents with sources of pollutants and symptomology of pollution injury.

In July of 1971 field report forms (Appendix) were distributed to the county agents and field investigations and verification of damage reports was begun. Identification of the suspected pollutant was based on visible symptoms and vegetation samples were processed through the Plant Diagnostic Lab, Suburban

Experiment Station for verification and further analyses for plant diseases. Consideration was given to cultural and climatic influences when evaluating injury.

Estimates of economic losses were based on grower costs and crop value at the time of harvest and the possibility of recovery of the crop following the pollution incident was taken into account. Losses to growers were based on the potential value of the crop without injury and actual value from market returns. Losses reflect reductions in yield and/or quality and profit losses when compared to previous years. Most loss estimates were made by the growers from daily or monthly market returns and many estimates had to be revised either up or down after yearly market receipts were received by the growers and their books had been balanced.

Direct losses include grower profit losses, reduction in yield and/or quality and were based on observed injury from air pollution or records of previous air pollution injury. Again, cultural and climatic factors were taken into accojnt when estimating these losses. Indirect losses attributable to air pollution include costs to replace a sensitive crop with a tolerant one, aesthetic considerations, and farm abandonment. Indirect losses were either absorbed by the growers prior to this survey or could not be assessed in the time available and they are, therefore, not included in this report.

Monthly progress reports stating where the pollution incident occurred, the suspected pollutant, the crop affected, and the approximate amount of damage were prepared for all co-operating agencies.

RESULTS

Field investigations were made in 40 of the 59 counties of the six New England states. Massachusetts, Connecticut, and Rhode Island were covered

completely and selected farmland areas and greenhouses were investigated in the other states. Field investigations were made either in response to verify a report or by independant examination by survey personnel of the Suburban Experiment Station. Not all investigations revealed injury to vegetation from air pollution. Direct air pollution injury was observed in 14 counties and accounted for 29 of the 83 reports filed (Table III). Injury resulting from air pollution occurred primarily on farmland or in greenhouses located in or near metropolitan areas (Figure 1).

Eighteen reports of injury were submitted for Massachusetts, four for Vermont three for New Hampshire, one for Maine, and three for Connecticut. No injury to commercial plants resulting from air pollution was reported for Rhode Island; however, injury to forest trees and other non-commercial vegetation was observed. Due to limited personnel available, no assessment could be made of losses incurred from injury to non-commercial plants such as home-garden plants, flowers, or ornamental plantings. The crops affected and the suspected pollutants are summarized in Table IV.

From data obtained through this survey in 1971, past agricultural statistics, and records made available by individual growers, it was determined that fruits, vegetables, and agronomic crops suffered the greatest losses. These crops accounted for about $1.1 million in losses. Losses in excess of $20 thousand were realized for commercial flowers and foliage plants (Table V). Lawn grasses, shrubs, and woody ornamentals did not suffer severe damage and any injury did not contribute to the total loss. Any reductions in timber production incurred prior to and during 1971 could not be directly attributed to air pollution injury. The nursery and turf industries suffered no apparent losses from air pollution injury. The total amount of damage during the 1971-72

Table III. Summary of vegetation damage reports by location.

State/County	Pollutant	Number of Reports Investigated
Massachusetts		
Barnstable	Oxidant	3
Bristol	SO_2	4
Essex	Oxidant	1
	SO_2	1
Hampshire	Oxidant	3
Middlesex	Oxidant	1
Plymouth	Oxidant	3
Worcester	Ethylene	2
Vermont		
Bennington	Oxidant	1
Orange	Ethylene	1
Rutland	Oxidant	1
Windsor	Oxidant/SO_2	1
New Hampshire		
Merrimack	Oxidant	2
	SO_2	1
Maine		
Lincoln	Oxidant/SO_2	1
Connecticut		
Hartford	Oxidant	3

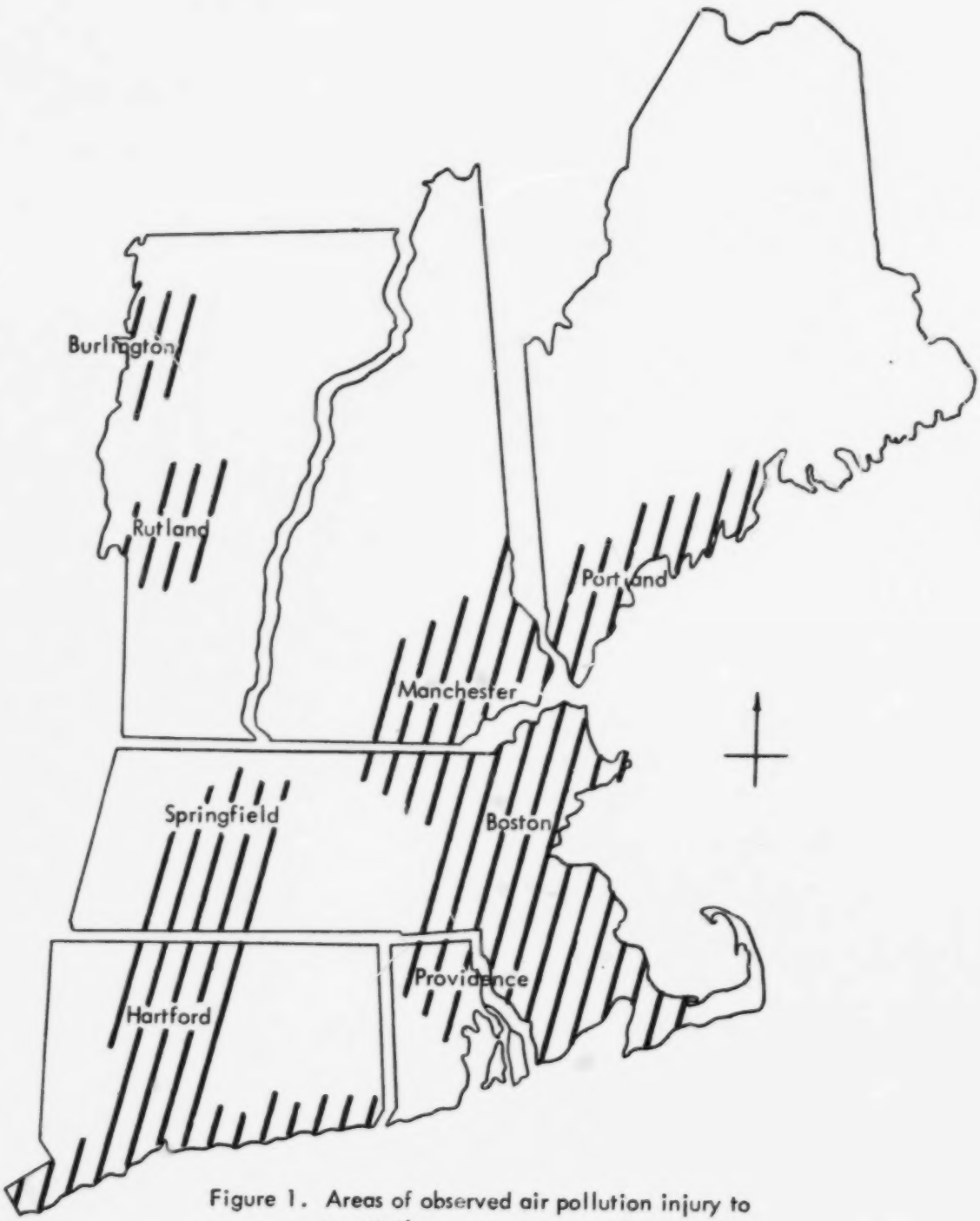

Figure 1. Areas of observed air pollution injury to vegetation.

Table IV. Crops affected by particular pollutants.
(Data from field observations, May 1971–July 1972)

Oxidants	SO_2	Ethylene	Oxidant/SO_2
Cucumber	Apple	Carnation	White Pine
Eggplant	Corn	Orchid	
Lilac	Geranium		
Petunia	Peach		
Potato	Pear		
Pumpkin	Plum		
Spinach			
Summer Squash			
Tobacco			
Tomato			
Watermelon			

Table V. Direct losses ($ thousands) by crop and pollutant.

Pollutant/Crop	Estimated Loss Before May 1, 1972	Revised Estimated Loss After May 1, 1972 *	Total
Oxidants			
Agronomic crops and Tobacco	60	+ 20	80
Vegetables	1,260	-300	960
Flowers and Foliage plants	3	+ 2	5
Fruits	None	None	---
SO_2			
Agronomic crops and Tobacco	45	- 2.5	43.5
Vegetables	None	None	---
Flowers and Foliage plants	3		3
Fruits	35	- 5	30
Ethylene			
Agronomic crops and Tobacco	None	None	---
Vegetables	None	None	---
Flowers and Foliage plants	14		14
Fruits	None	None	---
Totals	1,420.0	-285.5	1,135.5

* Many of the estimates were revised after the growers received market receipts and reviewed their financial statements. (see text)

Table VI. Summary of losses ($ thousands) by crop and pollutant

Crop	Pollutant			Total
	Oxidants	SO_2	Ethylene	
Agronomic crops and Tobacco	80	43.5	---	123.5
Vegetables	960	---	---	960
Flowers and Foliage plants	5	3	14	22
Fruits	---	30	---	30
Totals	1,045	76.5	14	1,135.5

survey period was estimated to be less than $1.5 million, or less than 1% of the total production receipts for New England. Incidents not reported by the county agents or observed by the survey personnel, accidental fumigations which are not expected to be a problem in the future because of control measures, and the fact that observed pollution injury to New England vegetation was not as great as in previous years, all contribute to the estimate which is believed to represent a fairly realistic figure for continuing annual losses. In some cases reports of injury lead to litigation and in one case the contributing source has been controlled. In other cases tolerant crops have been substituted for sensitive crops grown near continuing pollution sources and may indicate indirect losses.

Based on economic losses and injury with no apparent loss, the major pollutants in the New England region are, in order of importance, oxidants, sulfur oxides, and in localized incidents, ethylene, particulates, and very locally, fluorides.

Aesthetic considerations, although not included in this assessment, were quite significant and losses were noted on several thousand acres of forested land. Losses in aesthetic value came primarily from the so-called Eastern White Pine needle-blight which has affected many acres and is generally believed to be caused by an oxidant-SO_2 synergism.

In general, the effects of air pollution-caused vegetation injury were not severe enough to cause many indirect losses. As far as could be determined, no growers have relocated or abandoned farms because of air pollution; nor can erosion, stream silting, or deforestation be attributed to air pollution injury to vegetation in the New England region.

DISCUSSION

This survey is a first attempt to obtain a reliable estimate of economic losses due to air pollution injury for the agricultural industry of the New England region. The estimates of losses reported in this report come from experience, value judgements, use of the most recent agricultural statistics, and are based on observed visible symptoms of injury. It is important to realize the problem involved with using expressed symptoms as the bsis for this type of estimate. In many cases it was extremely difficult to determine the amount of permanent damage that would result in reductions of yield or quality. For example, a field of tomatoes was observed to have moderate foliar injury from oxidants after a period of temperature-inversion. When observed a month later after a period of local rains, all the plants had outgrown the injury and losses in yield or quality could not be demonstrated. There are also effects on plants which have no visible symptomatology but may affect vigor and ultimate yield of the plant. At the present time there are no guidelines for the assessment of this type of injury and it is obvious that research on these problems should have a very high priority.

Direct losses, as reported in this survey, include production costs as well as grower profit losses. Profit losses may result from reduced yields, selling in a lower quality category, or selling on a late market. It is interesting to note that most of the major agricultural areas of New England are in or near large metropolitan areas. Although permanent injury was not great, production of some crops was delayed enough to necessitate selling on a late market after prices had dropped. No crops were lost entirely, but quality of some crops was reduced several grades. With

some crops where quality was reduced it was extremely difficult to assess the loss.

The vegetable industry suffered the largest losses, probably due to the proximity of vegetable growing areas to large metropolitan areas. Also, the development of tolerant species has not progressed as quickly with vegetables as it has with other crops. Tobacco is a $40 million industry in the Connecticut River valley of Massachusetts and Connecticut, but because growers use tolerant varieties very little loss was realized.

For most of the 1971-72 growing season pollutant levels in New England were lower than in previous years and the reports of air pollution injury to vegetation were fewer. This lack of injury may be due to the occurrance of fewer pollutant-trapping temperature-inversions and to conditions unfavorable for injury when an inversion did occur. Plants are more sensitive to pollutants when they are young and when growing conditions are optimum. Most injury was reported in the springs of 1971 and 1972. However, when large-scale inversions occurred later in the summer, the plants had passed the age of maximum sensitivity and very little injury was reported during these months. Injury from sulfur oxides and ethylene was most extensive on greenhouse crops during the winter and very early spring months.

In August of 1972, although not included in this survey period, the pollution levels were much higher. A large temperature inversion covered the entire east coast and oxidant levels as high as .47 parts per million in Washington, D. C. and .30 ppm in Boston were reported. This inversion occurred after a period of extensive rainfall and injury to vegetation was reported to be quite severe, but no estimate of the extent of injury is available at this time.

RECOMMENDATIONS

1. An area the the size of New England cannot be sufficiently surveyed by one man in the field. It is recommended that there be at least three investigators, preferably plant pathologists and an entomologist trained in the recognition of air pollution injury to vegetation.
2. A training program at the beginning of the survey to acquaint county agents with air pollution symptomatology is a necessity, however, attendance must be emphasized in order to get the necessary co-operation during the field work.
3. News releases issued during the survey period could aid co-operation and would certainly keep the public informed about the progress of the survey.
4. Prompt reporting of air pollution injury must be emphasized to facilitate field investigations.
5. The survey should be conducted over a period of several years to take into account the yearly differences in pollutant levels and to insure a more accurate and reliable estimate of continuing annual losses.

APPENDIX: Air pollution injury report form.

REFERENCES

A survey and assessment of air pollution damage to California vegetation in 1970. Arthur A. Millecan. Bureau of Plant Pathology, California Department of Agriculture, Sacramento, California. 1971.

Agricultural Statistics, 1971. United States Department of Agriculture, Washington, D. C. 1971.

Assessment of air pollution damage to vegetation in Pennsylvania, 1970-1971. N. L. Lacasse. Center for Air Environment Studies, The Pennsylvania State University, University Park, Pennsylvania. CAES Publication No. 209-71. 1971.

Economic effects of air pollution externalities, with a case study of the greenhouse industry in southeastern Pennsylvania. James W. Carroll. Center for Air Environment Studies, The Pennsylvania State University, University Park, Pennsylvania. CAES Publication No. 235-72. 1972.

Economic impact of air pollutants on plants in the United States. H. M. Benedict, C. J. Miller, and R. E. Olson. Stanford Research Institute, Menlo Park, California. SRI Project No. LSD-1056. 1971.

Handbook of effects assessment: vegetation damage. Edited by N. L. Lacasse and W. J. Moroz. Center for Air Environment Studies, The Pennsylvania State University, University Park, Pennsylvania. 1969.

Statewide survey of air pollution damage to vegetation--1969. Center for Air Environment Studies, The Pennsylvania State University, University Park, Pennsylvania. Publication No. 148-70. 1970.

AIR POLLUTION INJURY REPORT

DATE _____ LOCATION: _____ REPORTER _____
(CITY/COUNTY/STATE)

GROWER _____ CROP & VARIETY _____

AGE OR DATE PLANTED _____ EXPECTED HARVEST DATE _____

AEREAGE AFFECTED _____ OR NO. OF PLANTS _____

AVERAGE % OF EACH PLANT AFFECTED: 0-10, 11-25, 26-50, 51-75, 76-99, 100
(CIRCLE ONE)

AVERAGE % OF PLANTS AFFECTED: 0-10, 11-25, 26-50, 51-75, 76-99, 100
(CIRCLE ONE)

LOSS IN: QUALITY _____, QUANTITY _____
(CHECK ONE OR BOTH)

ESTIMATED CROP LOSS: _____ % AND/OR $ _____

SUSPECTED POLLUTANT: SO_2, OXIDANT, OTHER (SPECIFY) _____
(CIRCLE)

SUSPECTED SOURCE _____ DATE OF INCIDENT _____
(OR WHEN NOTICED)

REMARKS:

USE SEPARATE SHEET FOR EACH CROP AND SEND TO C. JEFFREY BRANDT, SUBURBAN EXPERIMENT STATION, 240 BEAVER STREET, WALTHAM, MASS. 02154. YOUR COOPERATION IS GREATLY APPRECIATED.

C. Jeffrey Brandt

C. JEFFREY BRANDT

ENVIRONMENTAL PROTECTION AGENCY

TECHNICAL PUBLICATIONS BRANCH
OFFICE OF ADMINISTRATION
RESEARCH TRIANGLE PARK, N.C. 27711

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
ENVIRONMENTAL PROTECTION AGENCY
EPA - 335

SPECIAL THIRD-CLASS RATE
BOOK

RECEIVED
NATIONAL TECHNICAL
JAN 30 1973
INFORMATION SERVICE

UNITED STATES · ENVIRONMENTAL PROTECTION AGENCY ·